CLAIMS

What is claimed is:

1. An apparatus for attaching a filamentary member to a substrate having a plastic layer, said apparatus comprising:

a support surface for supporting said substrate and being engageable therewith;

a needle movable relatively to said support surface and adapted to penetrate said substrate to form an opening through said substrate; and

a swaging tool having a swaging surface facing said support surface, said swaging tool and said support surface being movable relatively to one another so as to compress said substrate between said swaging surface and said support surface, said swaging tool having a passageway therein for receiving said filamentary member, said passageway being alignable with said opening in said substrate, said filamentary member being positionable through said passageway and into said opening, said swaging surface deforming a portion of said plastic layer around said opening so as to swage said filamentary member to said substrate.

2. An apparatus according to Claim 1, further including a biasing spring on which said swaging tool is mounted, said biasing spring for biasing said swaging tool against said substrate.

3. An apparatus according to Claim 2, wherein said biasing spring is a pneumatic spring comprising a piston movable within a cylinder.

4. An apparatus according to Claim 1, further including a heater mounted on said needle, said needle being heated and melting said portion of said plastic layer upon forming said opening in said substrate.

5. An apparatus according to Claim 1, wherein said support surface defines an aperture therethrough, said needle being positioned in alignment with said aperture and movable therethrough to extend outwardly from said support surface and penetrate said substrate layer.

6. An apparatus according to Claim 5, further comprising an outer sleeve positioned in alignment with said aperture and having a lengthwise oriented bore for receiving said needle therein, said outer sleeve being movable relatively to said needle to extend outwardly from said support surface and penetrate said substrate layer, said bore of said outer sleeve forming a guide for directing said filamentary member into said opening in said substrate when said needle and said outer sleeve have penetrated said substrate and said needle is moved away from said substrate relatively to said outer sleeve.

7. An apparatus according to Claim 1, further comprising a stripper tube having a lengthwise bore therethrough, said swaging tool being positioned within said stripper tube bore and movable relatively thereto, said stripper tube being movable relatively to said support surface and having an end engageable with said substrate for separating said substrate from said swaging tool when said swaging tool is moved away from said substrate relatively to said stripper tube.

8. An apparatus according to Claim 7, further including a biasing spring on which said stripper tube is mounted, said biasing spring for biasing said stripper tube against said substrate.

9. An apparatus according to Claim 8, wherein said biasing spring is a coil spring.

10. An apparatus according to Claim 1, wherein said swaging surface has a concave conical shape.

11. An apparatus according to Claim 1, wherein said swaging surface is positioned so as to be directly engageable with said plastic layer.

12. An apparatus for attaching a filamentary member to a substrate having a plastic layer, said apparatus comprising:

a fixed support surface having an aperture therethrough, said substrate being positionable in facing relation with said support surface adjacent to said aperture;

a needle movable lengthwise through said aperture toward and away from said substrate, said needle having an end adapted to penetrate said substrate and form an opening therein;

a stripper tube having an end positioned facing said support surface and engageable with said substrate, said stripper tube being movable lengthwise toward and away from said support surface and having a lengthwise bore aligned to receive said needle therein;

a swaging tool positioned within said stripper tube bore and movable lengthwise relatively to said stripper tube, said swaging tool having a

lengthwise oriented passageway therethrough for receiving said filamentary member, said swaging tool having a swaging surface at one end engageable with said substrate; and

said substrate being penetrated by said needle when said needle is extended from said support surface and said stripper tube end is moved into engagement with said substrate thereby forcing said needle through said substrate and creating said opening, said filamentary member being insertable through said passageway and into said opening upon movement of said needle out of said opening, said filamentary member being attached to said substrate upon movement of said swaging tool into engagement with said substrate and compressing said substrate against said support surface, said swaging surface swaging a portion of said plastic layer surrounding said opening into contact with said filamentary member thereby fixing it to said substrate.

13. An apparatus according to Claim 12, further including a heater mounted on said needle, said needle being heated and melting said portion of said plastic layer upon forming said opening in said substrate.

14. An apparatus according to Claim 12, further comprising:

a first cam rotatable about a first axis;

a first cam follower engaging said first cam and mounted on said stripper tube, said first cam moving said stripper tube toward and away from said support surface;

a second cam rotatable about a second axis;

a second cam follower engaging said second cam and mounted on said swaging tool, said second cam moving said swaging tool toward and away from said support surface;

a third cam rotatable about a third axis;

a third cam follower engaging said third cam and mounted on said needle, said third cam moving said needle through said aperture to extend from or retract beneath said support surface; and

said cams being shaped and rotated so as to coordinate the relative motion of said stripper tube, said needle and said swaging tool for swaging said filamentary member to said substrate.

15. An apparatus according to Claim 14, further comprising an outer sleeve positioned within said aperture and having a lengthwise oriented bore for receiving said needle therein, said outer sleeve being movable relatively to said needle to extend outwardly from said support surface and penetrate said substrate layer, said bore of said outer sleeve forming a guide for directing said filamentary member into said opening in said substrate when said needle and said outer sleeve have penetrated said substrate and said needle is moved away from said substrate relatively to said outer sleeve.

16. An apparatus according to Claim 15, further comprising a fourth cam rotatable about a fourth axis, and a fourth cam follower engaging said fourth cam and mounted on said outer sleeve, said fourth cam moving said outer sleeve through said aperture to extend from or retract beneath said support surface in cooperation

with said needle, said stripper tube and said swaging tool.

17. An apparatus according to Claim 12, further comprising a pair of rollers mounted for rotation in opposite directions and having respective circumferential surfaces engaging said filamentary member on opposite sides thereof, said rollers being positioned above said swaging tool and, upon rotation, feeding said filamentary member through said passageway of said swaging tool and into said opening in said substrate.

18. An apparatus according to Claim 12, further comprising a frame for supporting said substrate, said frame being positioned between said support surface and said stripper tube and being movable transversely thereto for positioning a predetermined location on said substrate beneath said swaging tool for attachment of said filamentary member at said predetermined location.

19. A method of attaching a filamentary member to a substrate having a plastic layer, said method comprising the steps of:

forming an opening through said substrate at a predetermined location on said substrate;

inserting said filamentary member through said opening; and

deforming a portion of said plastic layer surrounding said opening into contact with said filamentary member.

20. A method according to Claim 19, wherein said deforming step includes swaging said portion of said plastic layer.

21. A method according to Claim 20, further comprising the step of swaging said portion of said plastic layer into a conical shape surrounding said filamentary member.

22. A method according to Claim 19, wherein said deforming step includes melting said portion of said plastic layer.

23. A method according to Claim 22, wherein said deforming step includes fusing said portion of said plastic layer to said filamentary member.

24. A method according to Claim 23, further comprising the step of fusing said portion of said plastic layer into a conical shape surrounding said filamentary member.

25. A substrate comprising a plastic layer, and a filamentary member extending transversely through said substrate and attached thereto by deforming a portion of said plastic layer surrounding said filamentary member into contact with said filamentary member.

26. A substrate according to Claim 25, wherein said portion of said plastic layer is deformed into a conical shape surrounding said filamentary member.

27. A substrate according to Claim 25, wherein said filamentary member is oriented substantially perpendicular to said substrate.

28. A substrate according to Claim 25, further comprising a textile material laminated with said plastic layer.

29. A substrate according to Claim 28, wherein said textile material is selected from the group consisting of woven, knitted and braided textiles.

30. A substrate according to Claim 28, wherein said textile material comprises a felt.

31. A substrate according to Claim 25, wherein said portion of said plastic layer is fused to said filamentary member.

32. A substrate according to Claim 31, wherein said portion of said plastic layer is deformed into a conical shape surrounding said filamentary member.

33. A substrate according to Claim 25, wherein said filamentary member comprises an optical fiber.

34. A substrate according to Claim 33, wherein said optical fiber is oriented substantially perpendicular to said substrate.

35. A substrate according to Claim 33, wherein said optical fiber has an outer cladding layer and said portion of said plastic layer is fused with said cladding layer.

36. A substrate according to Claim 35, wherein said portion of said plastic layer is formed into a conical shape surrounding said optical fiber.